SPATIOTEMPORAL ASSESSMENT AND VALUATION OF PROVISIONING ECOSYSTEM SERVICES OF PAKISTAN

SHEDAYI, A. A.[1,2,3] – XU, M.[1,4*] – GONALEZ-REDIN, J.[5] – HAGIST, S. C. N.[6] – ASLAM, S.[7] – KHAN, N.[8]

[1]*Key Laboratory of Ecosystem Network Observation and Modelling, Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences Beijing 100101, China*

[2]*University of Chinese Academy of Sciences, Beijing 100049, China (arshadbio@kiu.edu.pk)*

[3]*Department of Biological Sciences, Karakoram International University Gilgit 15100, Pakistan*

[4]*Department of Ecology, Evolution, and Natural Resources, Grant F. Walton Center for Remote Sensing & Spatial Analysis, School of Environmental and Biological Sciences Rutgers University 14 College Farm Road New Brunswick, NJ 08901-8551, USA*

[5]*The James Hutton Institute Craigibuckler, Aberdeen, AB15 8QH Scotland, UK*

[6]*Freeman Spogli Institute for International Studies, Stanford University Stanford, CA 94305-6055, USA*

[7]*MOE Key Laboratory for Biodiversity Science and Ecological Engineering College of Life Sciences, Beijing Normal University, Beijing, China*

[8]*Department of Botany, University of Malakand, Lower Dir, Khyber Pakhtunkhwa 18800, Pakistan*

[*]*Corresponding author*
e-mail: mingxu@crssa.rutgers.edu

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Abstract. Developing countries are often beset by poverty and hunger. While provisioning ecosystem services (Prov.ES) are essential for eradication of these issues, they are being rapidly depleted due to climate change and anthropogenic impacts. However, their depletion has not been accounted for in sustainable use policy. Taking Pakistan as a case study, this research focuses on assessing and evaluating the dynamics of Prov.ES. It evaluates the contribution of Prov.ES to poverty reduction using key indicators over different spatiotemporal scales. Among provisioning services, livestock's contribution was the highest, followed by agricultural products, while fisheries and forests contributed the least. Prov.ES were shown to be important to Pakistan's economy. Product analysis revealed that livestock was the most contributing service (53%), followed by agriculture (44%), while fisheries and forests contributed to a smaller extent (≤2%). Livestock products, major crops, marine fish products, and medicinal plants are the main contributors in those respective fields. Our results showed a net present value of 569 US$/ha/year, which is very close to the median value of the 16 previous studies analyzed. Incorporating natural resource conservation into sustainable development policies, with a focus on the impacts of climate change and the increasing human population, is essential.

Keywords: *conservation, food security, human well-being, poverty reduction, valuation*

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Introduction

Poverty, hunger, and food, water and energy security are key issues in the contemporary developing world (Hanjra and Qureshi, 2010). In 2013, 10.7% of the world's population was estimated to live on less than US$1.90 a day (World Bank, 2016). The increasing human population and the resulting degradation of natural resources and climate change are the main causes of drought and poverty (Kraus, 2016). The effects of climate change on ecosystem service processes and flows are apparent (Wood et al., 2018), particularly in the developing world (Lam et al., 2016). The impacts of climate change need to be considered in policymaking for sustainable natural resource use and development (Halsnæs et al., 2014). People in developing countries rely on the provisioning ecosystem services (Prov.ES) for their livelihoods (Khan, 2012), for example, food, water, wood, and NTFPs (non-timber forest products) (MEA, 2005a).

ES functions and drivers are interlinked (Butler, 2006). The sources of Prov.ES, such as crops, livestock, fishery, and forestry, are influenced by other ES and processes (TEEB, 2010a). Food security and hunger have become serious issues in developing countries owing to exponential population growth (Rosegrant et al., 2014), resulting in malnutrition, especially among women and children (MEA, 2005b). The demand for food and food prices will increase as a result of population growth, climate change, and income growth (Rosegrant et al., 2014). Therefore, it is important to protect natural resources and increase production in all sectors linked to human livelihoods. Currently, agroecosystems cover about 40% of the terrestrial landform and provide humans with various Prov.ES, such as food, forage, bioenergy, and pharmaceuticals (Power, 2010). Furthermore, agroecosystems also support other types of regulating, supporting, and cultural ES, such as pest control, soil retention, nutrient cycling, flood control, water quality, carbon storage, climate and disease regulation, beauty, education, recreation, and tourism (Power, 2010). Livestock is widely recognized and valued as a source of food, income, employment, nutrients, and risk insurance. It directly supports 600 million poor smallholders in developing countries, contributing 17% of kilocalorie and 33% of protein consumption globally (Théwis, 2012). Both cropping and livestock husbandry offer many opportunities for sustainability by raising productivity and increasing resource use efficiency (Herrero et al., 2010). Forests provide different ES, including timber, fuelwood, medicines, and other NTFPs (Hlaing et al., 2017), and are home to 1.6 billion people around the globe (IUCN, 2012). Land clearing and deforestation cause floods, local climate change, and contamination of water (Tariq, 2015). The global fisheries sector supports 10–12% of the world population but climate change is predicted to reduce fisheries production by 35% by 2050 (Lam et al., 2016).

Many people in Pakistan depend on agriculture, it contributed 20.9% to GDP in 2014–2015 and 26.0% in 1997–1998 (Chandio et al., 2016). More than 43.5% of the rural population are engaged in this sector (Ahmed and Javed, 2018). Livestock, forestry, and fisheries account for 56.3%, 2.0%, and 2.1% (Chandio et al., 2015) of the agricultural industry, respectively. More than 8.0 million rural families are engaged in raising livestock, which plays an important role in poverty reduction improving socioeconomic conditions (Chandio et al., 2015). Pakistan has 4.8% forest cover area, but 60% of urban and 90% of the rural population depend on fuelwood as their primary source of energy (FAO_UN, 2010). Both inland and marine fish in Pakistan are a source of food (Nazir et al., 2015). Fisheries are important in the economies of developing countries. Pakistan's total coastline covers an area of approximately 300,270 km^2, where the fisheries and

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fishing industry are source of employment, income, and food, as well as a substantial amount of foreign exchange via exports (FAO-UN, 2016a).

The monetary value of ES has recently gained attention (Lienhoop et al., 2015). Market price-based valuation of ES is considered a valid method of estimating the contribution of Prov.ES to human wellbeing, especially in poverty reduction (Daw et al., 2016). In this work, a market price-based approach is used to assess and value the products of Prov.ES. Discounting on the net present value (NPV) of ES is used to explore the future values of ES regarding their sustainable use, policy framework, and intergenerational benefits (Sterner and Kyriakopoulou, 2012). The selection of discount rates depends on the type of ES and future impacts affecting their delivery and flow, such as climate change. Previous studies on ES discount rates reported mean values of 1–12% (Dutton et al., 2015). Most researchers suggest low discount rates since we cannot assume that there will be an abundance of natural resources available in the future (TEEB, 2010b).

Despite their importance, natural resources are being depleted by anthropogenic and climate change impacts; some studies have been undertaken, but still, there is a gap in linking ecosystem services with poverty reduction and informing policymakers for sustainable development through conservation and management. Based on the current level of natural resource degradation in Pakistan, the aims of this research were to: (i) conduct a spatiotemporal assessment and valuation of Prov.ES in Pakistan, (ii) assess the role of the major indicators in poverty reduction and livelihood, (iii) determine the status of the national ES versus other countries; and (iv) assess NPV based on different time horizons and discount rates. The findings of this study will be useful for informing policymaking bodies.

Materials and Methods

Study Area

Pakistan (803,940 km^2) is a predominantly mountainous and desertous country located at 23°37' North and 61°76' east in South Asia at the junction of Central Asia and the Middle East. The highest point is the mountain K2 (8,616.3 m), in the north, and the lowest point is the Arabian Sea (0 m). The 2017 population was 207,774,520, with a growth rate of 2.40%. Pakistan has four provinces (Punjab, Sindh, Khyber Pakhtunkhwa, and Baluchistan) and administers Azad Jammu and Kashmir (AJK) and Gilgit-Baltistan (unofficial province) (*Figure 1*). Pakistan can be divided into five major topographic areas, including mountains, deserts, plateaus, salt ranges, and plains. Pakistan has four seasons, and the temperature varies both seasonally and regionally; the southern part has a hot and dry climate, while the northwest has a temperate climate and the northern part is arctic. Temperatures range from -22°C in winter in the north to 50°C in summer in the south. The precipitation is 1500–2000 mm and 100–200 mm across north and south Pakistan, respectively (Sarfaraz et al., 2014).

Agriculture is the backbone of Pakistan, contributing 21% to the GDP, 43.5% to the livelihood of rural communities, and 43.5% of employment opportunities (GoP, 2013). Livestock is an important sub-sector of agriculture, accounting for 56.3% of this sector and 11.8% of national GDP (Khan et al., 2015). The area covered by natural forests is small (4.2% of the total area), contributing only 2% to the agriculture sector and 0.44% to GDP (FAO_UN, 2010). Fisheries are a potential income generation source in Pakistan, but its growth rate in 2013–2014 was only 0.87% (Altaf et al., 2015). Pakistan has the potential to increase its supply of Prov.ES, which will not only help generate income but

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also assist poor people because poverty is linked with the provision of natural resources (Irfan, 2007).

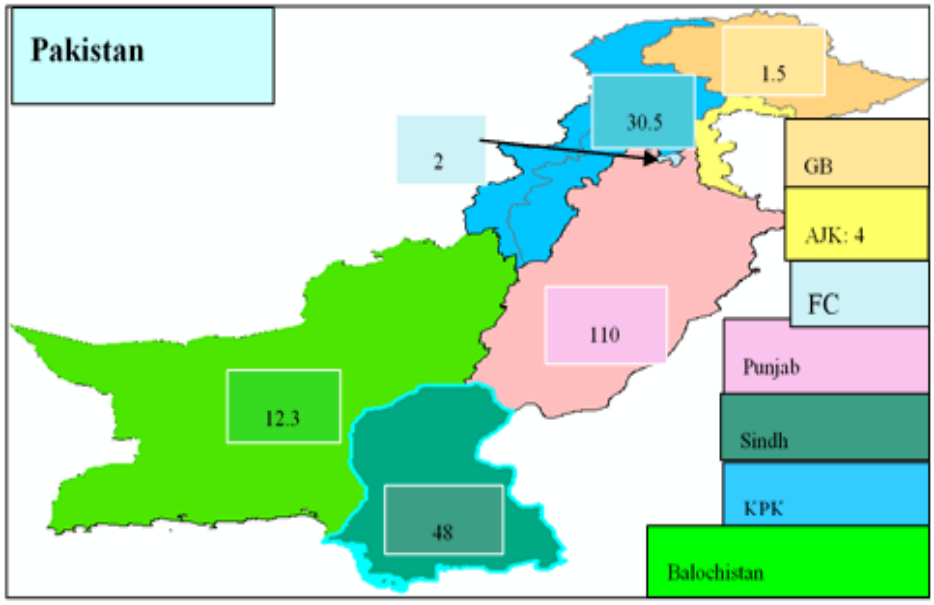

Figure 1. *Map of Pakistan showing the administrative units and population in millions from the 2017 census (Abbreviations: GB (Gilgit-Baltistan), AJK (Azad Jamu & Kashmir, FC (Federal capital), KPK (Khyber Pukhtunkhwa)*

Methods

Data for crops, livestock, and forestry were obtained from the respective government departments and the Pakistan Bureau of Statistics (PBS, 2015); relevant data for agriculture and forestry included area cover, quantity, and market prices. All data was obtained for the five-year period from 2011 to 2015, except for forestry data which was only available for the years 2009 to 2013 and the distribution of livestock by province which was based on 2011 and 2012 (PBS, 2017). The required data was extracted and analyzed for evaluation purpose.

The number of livestock, quantity produced, and market price were considered for livestock, and quantity and market price for fisheries. The market price method was used for direct use values for provisioning products, as in previous studies (Grădinaru, 2013; Siwar et al., 2016). Crops were classified as food crops, cash crops, pulses, and edible oilseeds, and were valued based on major and minor food crops. Major food crops included wheat, maize, rice, sugarcane, cotton, and their byproducts, while minor food crops included vegetables, fruits, condiments, oilseeds, and green fodder. Livestock was divided into major livestock and poultry. Forestry was divided into two main types: major forestry products such as timber and fuelwood and NTFPs; NTFPs is used throughout this research for all products except timber, fuelwood, wildlife, and bushmeat. The estimated value of each Prov.ES product was based on both spatial (by province, marine and inland) and temporal scales for 2011 to 2015 (*Table 1*). ANOVA was also used to describe the significance of variables for the ecosystem assets such as crop, livestock, forestry and fisheries.

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Table 1. *Provisioning ecosystem services assessed in this study*

*ESS asset	Sub-type	*Prov.ES type	Value	Method	Time period
Crops	Major and minor crops, fruits, vegetables	Food, trade	Use value	Market price	2011–2015
Livestock	Goats, sheep, cattle, poultry	Food, decoration, trade, manure	Use value	Market price	2011–2015
Forestry	Timber, fuelwood, *NTFPs	Construction, heating, medicine, food, agriculture, tools	Use value	Market price	2011–2015
Fisheries	Marine and freshwater	Food, trade	Use value	Market price	2011–2015

*ESS: ecosystem service, *Prov.ES: provisioning ecosystem service, *NTFPs: non timber forest products

The annual average of the five-year data was calculated to get the gross total value. The NPV, also known as net total value (NTV), for all the environmental assets was calculated using *Equation (1)*.

$$NPV = TGV - IC \quad \text{(Eq.1)}$$

where TGV = total gross value total value and IC = input cost. The ICs vary by environmental asset in agriculture and include seeds, fertilizers, water, electricity, tube wells, mechanization, and labor.

Discount rates of 0.74%, 6%, and 11.26% were applied to the NPV for time horizons of 35 (2050), 85 (2080), and 105 (2120) years to predict future NPV values using *Equation (2)*. A regression model with a 95% confidence interval was used to find the demand curve trend between the quantities and the values.

In Pakistan, the average interest/discount rate for 1992–2017 was 11.26% and the current (2016, 2017) discount rate is 6%. A discount rate of 0.74% was chosen as most scholars recommend a low discount rate to enhance intergenerational benefits. The future NPV was calculated using *Equation (2)* (Griffin, 2006).

$$\text{NPV} = \sum_{t=0}^{T} \frac{\text{NBt}}{(1+r)^t} = Co + \frac{\text{NBt1}}{(1+r)^t} + \frac{\text{NBt2}}{(1+r)^t} + \frac{\text{NBt3}}{(1+r)^t} + \quad \text{(Eq.2)}$$

where t = time period (years); T = planning horizon; NB_t = net benefits in period t; and r = discount rate.

The mean, median, standard error, standard deviation, and other statistical parameters were calculated for the NTV (NPV) and the NPV for 35 (2050), 70 (2080), and 100 (2020) year time horizons.

Our NPV was also compared with those from 16 previous similar studies performed worldwide. The studies were identified by searching for the keywords provisioning ecosystem service, valuation ecosystem service, and valuation of natural resources in the EVRI, Science Direct, and PubMed databases. After screening these articles/reports, based on the keywords, 16 were selected for comparison. Many of the studies did not report the total or unit value, so we calculated the values from these articles and converted all results to USD per hectare, which enabled comparison by mean, median, sum, standard deviation (SD), and maximum and minimum values.

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Results

Crops

The total area dedicated to crops in Pakistan is 17,769,000 ha, of which Punjab accounts for the greatest portion and Baluchistan the smallest. Cereals make up the greatest area, followed by fodder, whereas pulses, vegetables, and fruits are grown on merely 13% of the total area. During the period 2011–2015, an annual average of 19,392,000 ha was cultivated, with food crops making up the largest area followed by cash crops, whereas pulses and edible oilseeds covered only a small area. The mean was 16% over the five-year period (*Appendix A*). On average, 92,638,000 tons of agriculture commodities were produced annual over the five-year period (2011-2015), of which fodder production was the highest followed by cereals. The average cultivated crop production was 114,353,000 tons, among which food and cash crops contributed the most. In the study period, the lowest and highest production rates were in 2013 and 2014, respectively. Overall, production was highest in Punjab and lowest in Baluchistan (*Figure 2*). The production of crops at spatial scale were found non-significantly different in the provinces in and ANOVA test with F value 2.7766 and P value 0.0751 (at P >0.05), while the production of crop commodities found a significantly different from each other with F value of 523.710 and P value 3.55E-16.

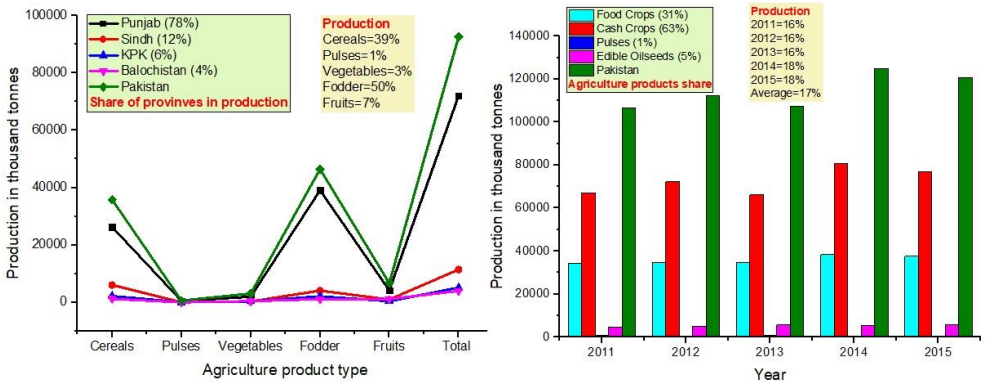

Figure 2. *Agricultural production by province for 2011–2015 (KPK: Khyber Pukhtunkhwa)*

The five-year average TGV, IC, and NPV for major crops and byproducts were 2,454,808, 552,581, and 1,902,227 million PKR, respectively. Wheat had the highest average NPV followed by cotton, while maize was the lowest. Crops had a higher NPV value (86%) than the byproducts (14%). The mean NPVs for the major crops and byproducts for 2011–2015 showed a statistically non-significant difference (p-value = 0.97825). The TGV, IC, and NPV values for minor crops and other agriculture products were found to be 950,199, 121,156 and 829,043 million PKR, respectively, with fruits the highest and pulses the lowest value. The NPV for the given period was found to be highest in 2015 and lowest in 2012, with an overall non-significant difference (p-value = 0.98144) in means (Figure 3). The NPV of the byproducts was 341,295 million PKR in which major crops contributed the more (85%) as compared to the minor crops (15%), over all wheat contributes the highest (55%).

The NPV for crops products consists of the value of the major crops, minor crops and byproducts was estimated to be 2,731,270 million PKR, of which the major crops (62%) and minor crops (28%) contributed more than the byproducts (10%) (*Figure 4*).

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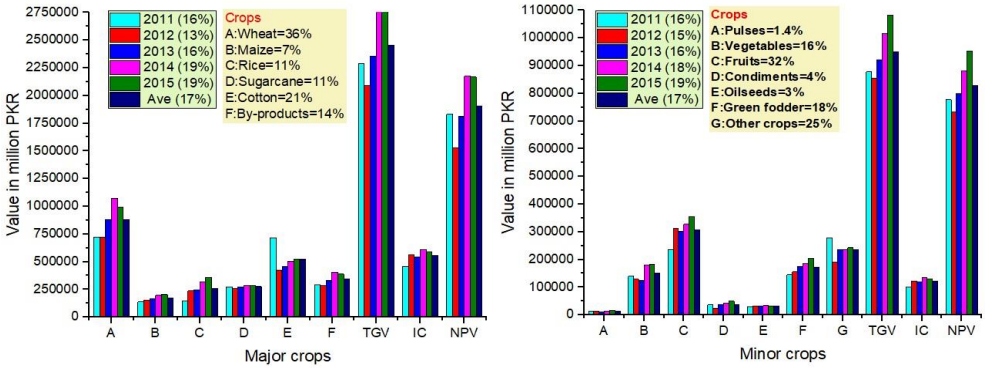

Figure 3. *Agriculture product type and value for 2011–2015. TC = total cost, BPs = byproducts, TGV = total gross value, IC = input cost, NTV = net total value*

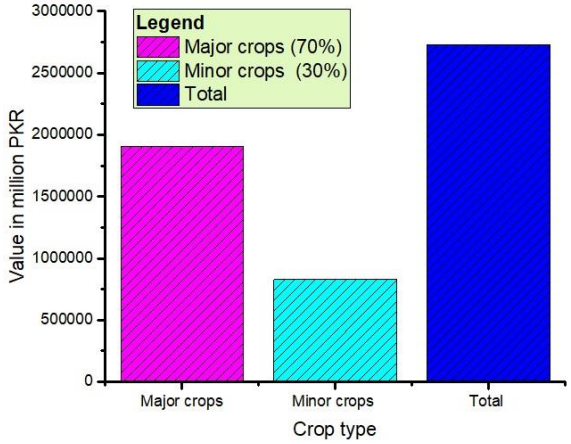

Figure 4. *Total value of agriculture products 2011-2015*

Livestock

The total livestock population was 219,147,000 in 2006, with the highest proportion in Punjab followed by KPK and Sindh. Excluding poultry, goats contributed the most (38%) followed by cattle, buffalo, and sheep. An increasing trend was observed in the number of livestock from 2011 to 2015 (*Figure 5*), but it was not significant with F value 0.0167 and p-value = 0.99904. From the five-year average total milk production, buffalo produced the most followed by cows. The total milk production for the study period tended to increase, although no significant difference (F-value 0.0064, p-value = 0.9991) was found. The five-year average meat production was 3,387,000 tonnes, with beef contributing the most followed by poultry and mutton, and an increasing trend was observed (*Figure 6*) It also showed a non-significantly different value (F-0.0484, p-value 0.9957).

Hide and skin production totaled 65,128,000 with goat the highest, followed by fancy and sheep. Egg, gut, and casings production totaled 80,384,000, of which guts contributed the most and eggs the least (*Appendix B*). Production of skin and hide from different animals showed significantly different values (F-value 1220.864, p-value 4.69E-28). There were 3,228,000 tonnes of other products, with dung, bones, offal, and urine being

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the main contributions (81%) (*Appendix C*). These products had also significantly different (F-Value 1012.288, p-value 2.84E-44) production for the 5 years' period.

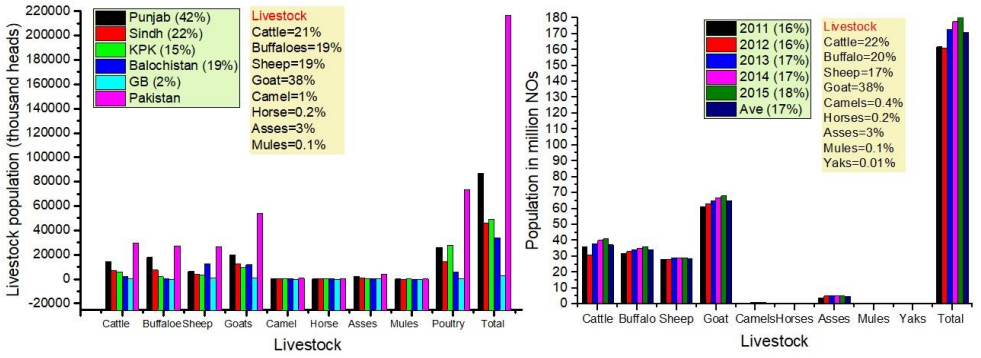

Figure 5. *Livestock type and population*

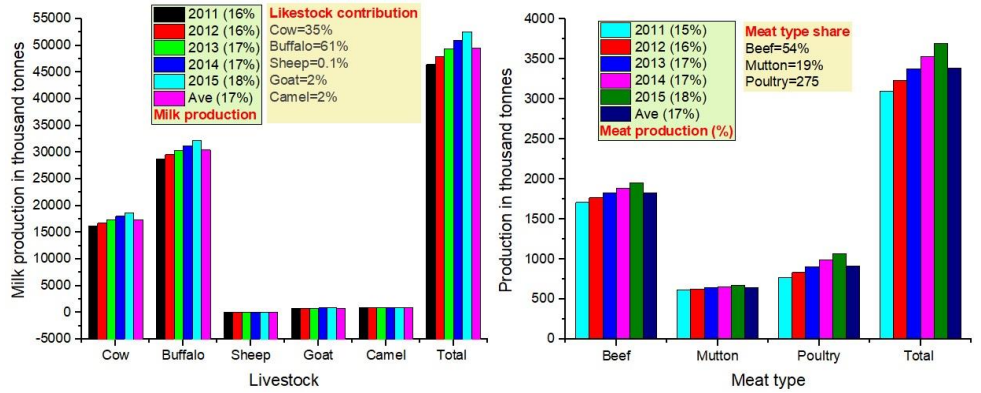

Figure 6. *Milk and meat type and production for 2011–2015*

The five-year average value of livestock was 3,242,691 million PKR, of which livestock products were highest and natural growth and regeneration were lowest. Among the products, the value of milk was the highest while wool and hair contributed the least. The analysis showed an increasing but not significant trend (p-value = 0.99343) (*Figure 7*).

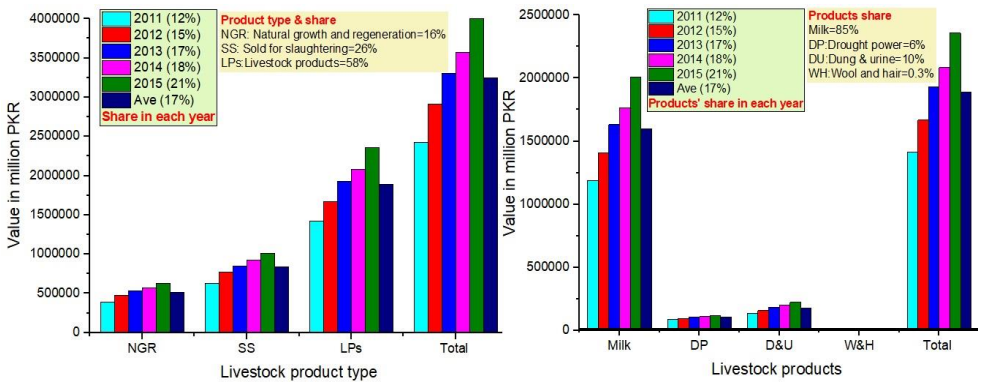

Figure 7. *Livestock product type and value for 2011–2015*

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Similarly, the average value of poultry products was 288,559 million PKR. Farmed chickens contributed the most followed by eggs. The TGV, IC, and NPV were 3,545,051, 634,885 and 2,910,166 million PKR, respectively. Livestock products contributed the most followed by animals sold and slaughtered while poultry products contributed only 8%. Sub-categories showed a generally increasing, but not significant (p-value = 0.945072), trend (*Figure 8*).

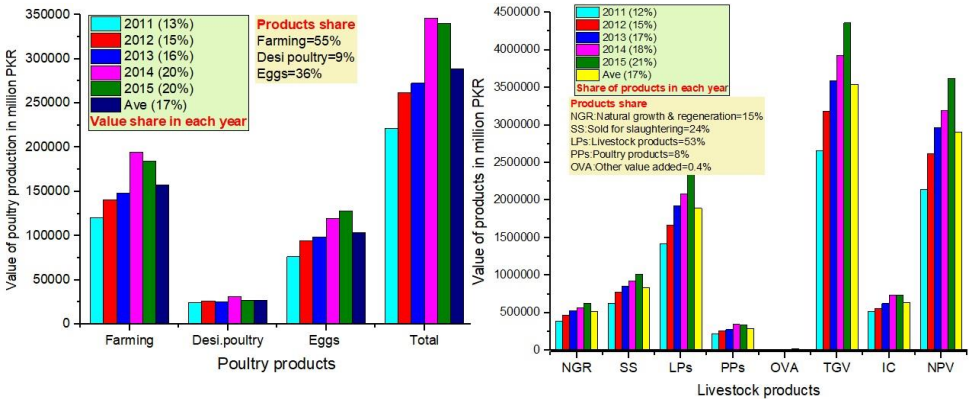

Figure 8. *Value of poultry and overall livestock products for 2011–2015*

Forestry

The total forest cover area in Pakistan is 11,032 thousand hectares, of which 60% and 40% is protected and unprotected, respectively. Punjab and Gilgit-Baltistan have the highest forest coverage (*Appendix D, Fig. 4*). The five-year average major forestry products were estimated to be 462 thousand cubic meters, and there was an increasing trend from 2009 to 2013. Firewood production was higher than timber production. These products had non significantly different values (F-value 2.3566, p-value 0.1632). There were estimated to be 147,478 tonnes of NTFPs, while others were produced in very low quantities. Production levels remained consistent over the study period (*Figure 9*). The five-year mean TGV of the NTFPs was 12,184 million PKR. The NPV was 10,472 million PKR, with medicinal plants contributing the most and vegetables the least. There was an increasing trend in the value of NTFPs from 2011 to 2015 (*Figure 10*).

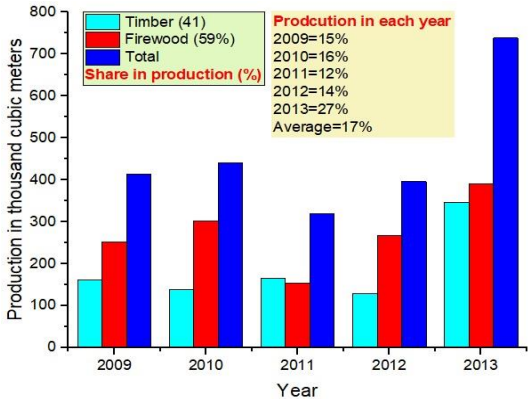

Figure 9. *Major forest products for 2011–2015*

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The five-year mean TGV and NPV of major forest products was estimated to be 1,757 and 1,732 million PKR respectively, in which timber contributed the most as compared to the firewood. An increasing trend in the value of the major forest products was observed from 2011 to 2015; that is, the highest value was in 2015 and the lowest was in 2011 (*Figure 11*). Overall, the NPV of forests was found to be 12,204 million PKR. In which NTFPs products contributed the most, while timber and fuelwood contributed the least. An increasing trend in the value of forestry products was observed from 2011 to 2015 (*Figure 11*).

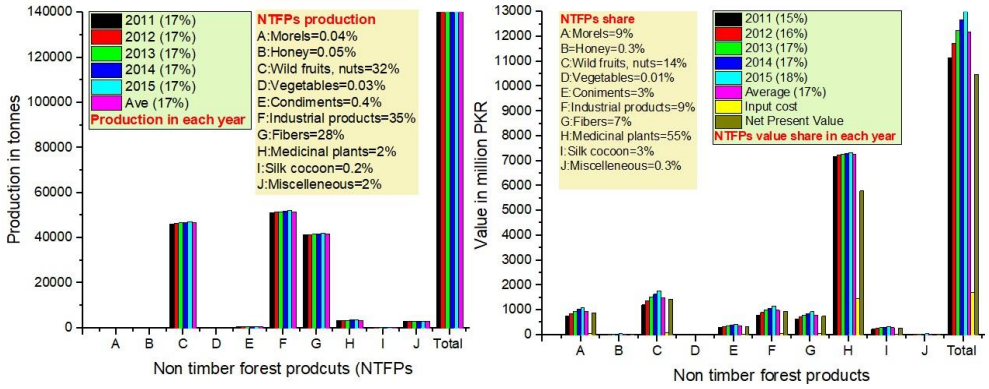

Figure 10. *Minor/Non-timber forest product types and values for 2011–2015*

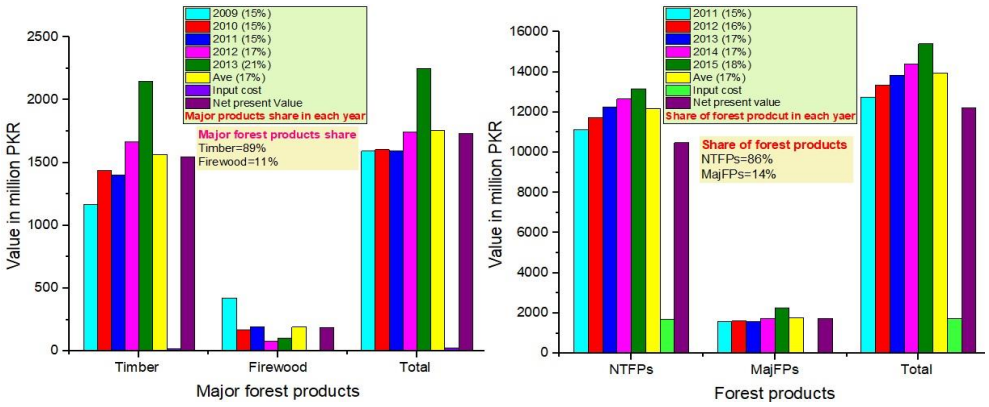

Figure 11. *Value of the major forest products (MajFPs) and net total value of forest products (NTFPs: non timber forest products)*

Fisheries

In Pakistan, the five-year mean total freshwater fish production was 238 thousand tonnes. There was an increasing trend from 2011 to 2015, freshwater fish production was highest in Sindh followed by Punjab, while there was no inland fish production in the Baluchistan province (*Figure 12*). The average annual marine fish production for the five-year period was 492 thousand tonnes, and again an increasing trend for fish production was found from 2011 to 2015. Sindh and Baluchistan were the only marine fish-producing provinces, accounting for 70% and 30% of production, respectively (*Figure 12*). The average total fish production in Pakistan was 730 thousand

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tonnes per year with an increasing trend from 2011 to 2015. There was an average 67% and 33% of fish production per year from marine and freshwater respectively. Province-wise, fish production was highest in Sindh (66%) followed by Baluchistan (20%), while KPK contributed the least (1%) (*Figure 13*). The spatial distribution of the total fish production was significantly different among the provinces with F-value 17136.97 and P-vale 2.93E-28, while the temporal distribution of the fish production was not different for the period 2010-2015 with F-value 0.000614 and p-value 0.9999.

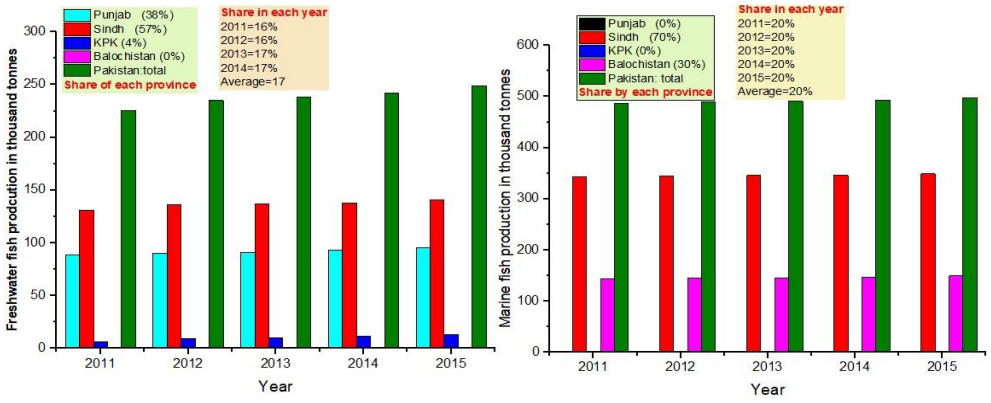

Figure 12. *Freshwater and marine fish production by province for 2011–2015 (KPK: Khyber Pukhtunkhwa)*

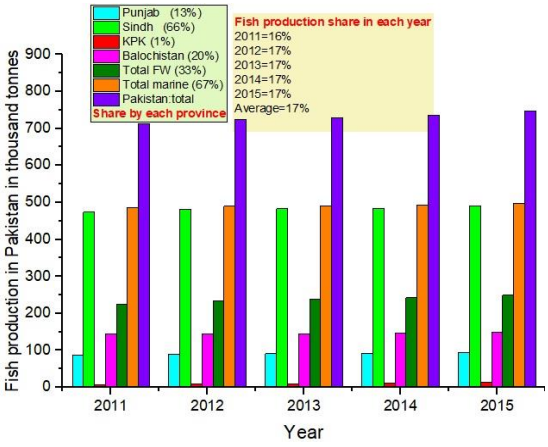

Figure 13. *Total fish production by province for 2011–2015 (KPK: Khyber Pukhtunkhwa, FW: freshwater)*

The five-year average TGV for freshwater fish was 51,755 million PKR, while the NPV was 41,404 million PKR. During the study period, the proportion of the freshwater value ranged from 12% to 21%, with the highest in 2015 and the lowest in 2011. Sindh contributed the most followed by Punjab (*Figure 14*). The average TGV of marine fish for the five-year period was 106,603 million PKR (17%) and the NPV was 85,283 million PKR. The marine fish value was highest in 2015 (20%) and lowest in 2013 (13%). The average NPV for marine fish in Punjab and KPK was zero, while Sindh contributed the most (70%) followed by Baluchistan (30%) (*Figure 14*).

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The five-year average TGV of fish production in Pakistan was found to be 158358 million PKR and the NPV was 126686 million PKR. The total market value of fish showed an increasing trend from 2011 to 2015. As a whole, marine fish value contributed higher (67%) than the freshwater fish value (33%). By province, Sindh contributed the most (66%) followed by Punjab (13%), while KPK contributed the least (1%) (*Figure 15*).

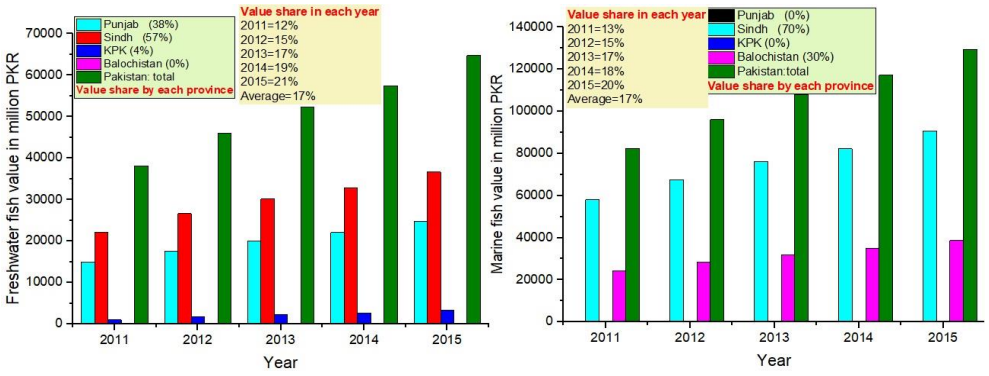

Figure 14. *Value of freshwater and marine fish by province for 2011–2015 (KPK: Khyber Pukhtunkhwa)*

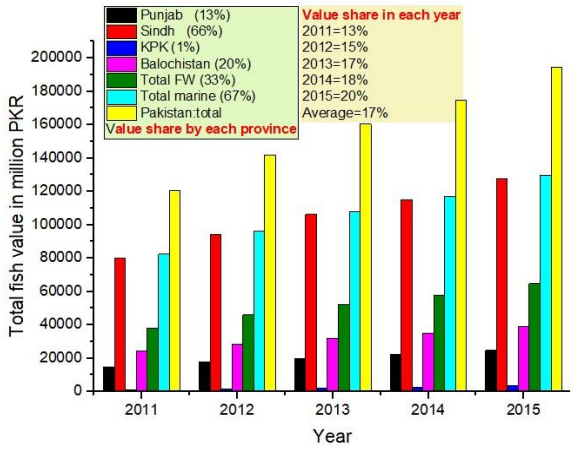

Figure 15. *Total fish value by province for 2011–2015 (KPK: Khyber Pukhtunkhwa, FW: freshwater)*

NPV and discounting for Provisioning Ecosystem Services

The mean NPV of provisioning services was estimated to be 5,471,304 million PKR for the period 2011-2015. The NPV for crop, livestock, forest, and fisheries was 2,390,715 (44%), 2,910,166 (53%), 35,105 (1%) and 135,318 (2%), million PKR respectively (*Figure 16*). Discounting rates of 0.74%, 6%, and 11.26% were applied to the NPVs for time horizons of 35, 70 and 105 years. The results clearly show that NPVs decreased with increasing discount rate and increasing time horizon as was expected. Results also shown for mean, SD, minimum and maximum values (*Table 2*).

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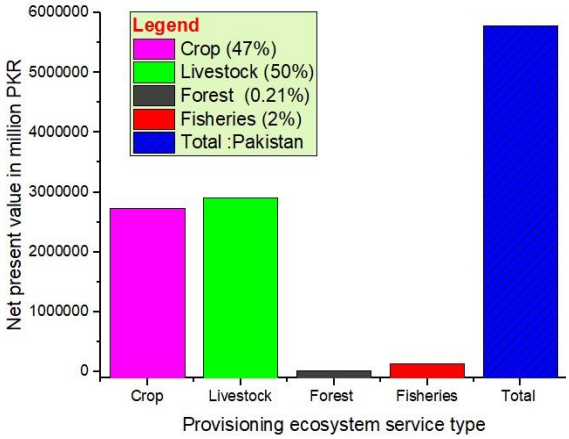

Figure 16. *Total value of provisioning ecosystem services*

Table 2. *Discount rates for different time horizons (value in PKR)*

ESS asset	Current	35 years (2050)			70 years (2085)			105 years (2120)		
Type	*NPV	0.74%	6%	11.26%	0.74%	6%	11.26%	0.74%	6%	11.26%
Agriculture	2390715	1846969	311044	57103	1426893	40469	1364	1102360	5265	33
Livestock	2910166	2248276	378628	69511	1736927	49261	1660	1341879	6409	40
Forest	35105	27121	4567	838	20952	594	20	16187	77	0.5
Fisheries	135318	104541	17606	3232	80764	2291	77	62395	298	2
Statistics										
Sum	5471304	4226907	711845	130684	3265537	92615	3121	2522821	12050	74.56
Mean	1367826	1056727	177961	32671	816384	23154	780	630705	3012	18.64
Standard error	748350	578145	97364	17875	446651	12668	427	345065	1648	10.20
Median	1263017	975755	164325	30168	753829	21380	721	582378	2782	17.21
*SD	1496700	1156290	194729	35749	893303	25335	854	690129	3296	20.40
Minimum	35105	27121	4567	838	20952	594	20	16187	77	0.48
Maximum	2910166	2248276	378628	69511	1736927	49261	1660	1341879	6409	39.66
Conf. level (95%)	2381584	1839915	309857	56885	1421444	40314	1359	1098150	5245	32.45

*NPV: Net present value, *SD: Standard deviation

Comparison with Other Studies

The Prov.ES values obtained in this work were compared with the results from 16 previous studies from around the world. The previous studies showed a sum of 96,985 USD/ha/y, mean 6062, SD 13731, median 666, minimum 7, and maximum 53736 USD/ha/y. While our results showed a value of 569 USD/ha/y, which is very close to the median value of the previous studies (*Figure 17*). Our results were consistent with many of the previous studies (Jenerette et al., 2005; Huxham et al., 2008; Paletto et al., 2008; Häyhä et al., 2015), although some of them presented very high values, ranging from 2,142 to 53,736 USD/ha/y (Chiabai et al., 2008; Wang et al., 2008; Martín-López et al., 2008; Chang et al., 2008; Molnar et al., 2008; Li et al., 2008), while others presented much lower values compared to our results (Fang et al., 2009; Voora and Barg, 2008; Hussain et al., 2008; de Groot et al., 2008; Dupras et al., 2008; Valatin and Starling, 2008).

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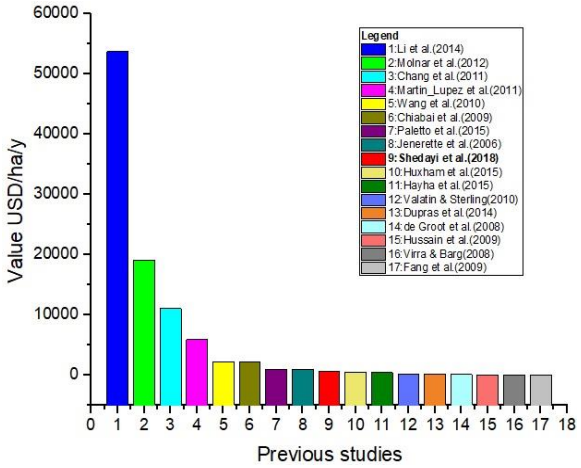

Figure 17. *Comparison with previous studies*

Discussion

Crops

Agriculture is a dominant land management technique globally, and agricultural ecosystems cover nearly 40% of the terrestrial surface on Earth (FAO, 2015a). In our case study, the products of agricultural ES were evaluated using standard market analysis. Valuing the Prov.ES that are derived from agriculture was relatively straightforward since agricultural commodities are traded in local, regional, or global markets (Power, 2010).

Agriculture is the backbone of Pakistan's economy, contributing 21% to the national GDP, and 43.5% of the labor force is engaged in agriculture (Chandio et al., 2015). Furthermore, it plays a vital role in ensuring food security, generating economic growth, reducing poverty, and the transformation towards industrialization. The major crops cultivated in Pakistan are wheat, rice, cotton, and sugarcane, which attribute for 29% of overall agriculture, while minor crops, e.g. oilseeds, potato and pulses, contribute 6% of GDP (PBS, 2015).

Owing to the demand from the increasing human and livestock populations, fodder is grown in large parts of the country, followed by cereal crops. These provide the basic requirements of humans and livestock. Cereal production requires a lot of resources and labor while fodder crops can be grown with little effort as compared to the food crops. Secondly, the demand for food of livestock is high, which is why in Pakistan fodder crops had the highest production followed by cereals, while the production of fruits, vegetables, and pulses is relatively low. Punjab had the highest production of crops, followed by Sindh, KPK, and Baluchistan, mainly because Punjab covers a larger area than the other provinces. Cash crops showed the highest production, followed by food crops, while edible oil seeds and pulses were produced at low levels because people prefer to grow crops that are more profitable. Statistically a non-significant increasing trend of agriculture production was observed from 2011 to 2015 because people have realized that they need to produce more to meet the demand from the increasing population.

Overall, in the agriculture sector, major crops contributed the most to NPV, followed by minor crops. There was a non-significantly increasing trend for both the major crop and overall NPV of agriculture products. This is because of the higher demand for the

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major crops as compared to the minor crops, and secondly, in most parts of the country, the climatic conditions are more suitable for the major crops than the minor crops.

The agriculture sector showed positive growth of 2.9% in 2015 compared to the previous years (2013 and 2014) (GoP, 2014). This is because of the improvement in the agricultural practices in Pakistan. The production of the agriculture commodities found significantly different from each other. In the agriculture sector, wheat was found to contribute the most served in the income followed by cotton, while other crops such as rice, sugarcane, and maize contributed very little. This is because Pakistan has favorable climatic and soil conditions for wheat growth and secondly the demand for wheat consumption is much higher than that for other crops because wheat foods are popular among the Pakistani people owing to their nutritional value; wheat is served in all three daily meals. It is grown in all the provinces and across a wide range of altitudes. Pakistan ranks fourth and third worldwide among cotton-growing and -consuming countries (PBS, 2015) because the climatic and edaphic conditions in Pakistan are suitable for growing cotton. The other crops include bajra, jowar, gram, barley, rapeseed and mustard, and tobacco. Pulses include masoor, mong, chana, and mash. Besides these, potatoes, onions and chilies are also grown to meet the requirements of the country at the local level.

Agricultural crops are not only important for their value as food for human beings, but also as a source of food for livestock. In many developing countries, some crops, such as maize, wheat, sorghum, and millet, are dual purpose: their grain provides food for humans and their residues are used as feed for livestock. In mixed crop–livestock systems, the value of the crop residues is sometimes as much as that of the grain itself owing to the importance of the residue as a feed for livestock, particularly in the dry season. In mixed agriculture systems, there are always tradeoffs; for example, people obtain milk products from the buffaloes and cows while and at the same time achieving high grain production by manuring their fields using cow or buffalo wastes.

This has increased the demand for dual-purpose crops with relatively high-quality crop residues, and burgeoning fodder markets have developed around cities such as Hyderabad in India (Blummel and Rao, 2006). The cropping–livestock mixed farming system is considered to be more beneficial than a single system. Mixed agro-pastoral systems produce close to 50% of the world's cereals and most of the staples consumed by poor people (Herrero et al., 2010). Depending on their structure and management, agroecosystems also contribute a number of other globally important ecosystem services (MEA, 2005a), such as supporting biodiversity and enhancing carbon sequestration (Power, 2010).

Livestock

Livestock production makes a large contribution to the GDP of developing countries. It is an essential activity that contributes multiple services, such as fertility of land, maintenance of biodiversity, food security, and cultural and rural vitality (Ryschawy et al., 2017). Sustainable farming based on environmental conditions is essential for the livelihood of people in developing counties (Herrero et al., 2009). Livestock contributed 11.8% of the country's GDP and 56.3% of the agriculture sector share of GDP in Pakistan (PBS, 2015). In the livestock sector, the average number of animals was 285 million with a non-significantly increasing trend during the period 2011-2015, of which goat contributed the most followed by cattle, buffalo, and sheep. People prefer to keep goats because they are easily handled and provide manifold benefits compared to other livestock. Goats provide meat, milk, hair, and manure. Most people in Pakistan prefer

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goat meat to fulfil their protein requirements that is also expensive in the market as compared to lamb and beef. People prefer to rear livestock that provide multiple benefits over livestock that provide only one benefit and are expensive to keep, such as asses, poultry, camels, horses, mules, and yaks. Punjab province has the highest population of livestock. Punjab is the most populated province so has more livestock. Milk production from buffaloes was highest followed by cows because these animals are large so produce more milk than smaller animals. In meat production, beef contributed the most followed by poultry and mutton owing to the size and number of animals. The production of livestock product was found non-significantly increasing from 2011-2015, while the production of skin, hide and other products from different animals was found significantly different. The average NPV for livestock was in a non-significantly increasing trend over the five years studied. Livestock-products contributed more to the NPV compared to animals slaughtered or kept live. Overall, milk was the dominant livestock product because people use milk on a daily basis and thus prefer to keep livestock that produce milk. Milk is used for various purposes, such as making tea, yogurt, lassy, and cheese, while meat is used less frequently, which is why milk makes a bigger contribution to NPV compared to the other products.

The economic benefits obtained from livestock are greater than those from the agricultural cropping system. Agro-pastoral and pastoral systems cover 45% of Earth's usable surface (Reid et al., 2008) and supply 24% of global meat production (Steinfeld et al., 2006). Projections show that in the next three decades 30% more grass will be required to meet the global demand for meat and milk and that improved management and use of fertilizers in parts of the world will be necessary to meet this increased demand (Herrero et al., 2009). Mixed agro-pastoral systems generate the bulk of livestock products in the developing world, that is, 75% of the milk and 60% of the meat, and employ many millions of people in farms, formal and informal markets, processing plants, and other parts of long value chains (Herrero et al., 2010).

Forestry

Forests play a significant role in any country's wellbeing and economy (Economics for the Environment, 2011). According to the FAO, the area coverage of the world's forests was 3,999 million ha in 2015, a decrease from 4,128 ha in 1990; forestry cover fell from 31.6% to 30.6% during this period. This change resulted from an increasing deforestation trend, especially in developing countries (FAO-UN, 2016b). Forest components, such as timber, fuelwood, and NTFPs, are important to the livelihood of people in developing counties (TEEB, 2009). In Pakistan, there are more protected forests than unprotected forests. Punjab and Gilgit-Baltistan have the biggest share of the total forest area followed by KPK. A non-significantly increasing trend in the production of major forest products was observed owing to increased plantation sizes in some parts, especially in KPK. Fuelwood production was greater than timber production. More NTFPs, including industrial products, wild fruits and nuts, and fibers, were produced than other NTFPs, such as medicinal plants, condiments, silk cocoons, honey, morels, and vegetables. In the NTV of forest products, NTFPs contribute the biggest share while other products, like timber and fuelwood, contributed very little to the NPV. There was an increasing trend of the NPV over the five-year period, because of the increased production and increasing market value each year. Timber made a higher contribution to the NPV than fuelwood because of its greater market value. Among the NTFPs, the medicinal

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plants' share of the NPV was much higher than for the other products. In addition, forest departments earn a substantial amount of revenue from forests.

Most of the population of Pakistan lives in rural areas, depending on natural resources for their livelihoods. In addition, there are many industries that depend on forest products, such as timber, processed wood and paper, rubber, and fruits. Forests provide essential services for rural agricultural communities, such as fuel, fodder, game, fruits, building materials, medicines, and herbs. A large number of livestock in rural communities, as well as wildlife, also depend on the forest ecosystem for their survival. Forests are blessings that help humans in many ways both in good times and in times of difficulty (Mitchell et al., 2014).

NTFPs play a very important role in the livelihoods of the people in the study area. They are a source of income for poor rural population (Ingram and Bongers, 2009) and provide job opportunities and sources of livelihood to a large number of people (Pandey et al., 2016). In addition, NTFPs are also an important source of foreign exchange; morels, for example, are exported entirely by local grocers (Wahlén, 2017). Honey production from beekeeping is an important source of income as well as being nutritious and having medical applications. In Pakistan, around 15,000 people are involved in beekeeping. Good quality honey production can be increased by modern beekeeping techniques with the introduction of European bees. Other wild NTFPs, including wild fruits, nuts, vegetables, condiments, wild pomegranate seeds, and caraway, are produced in small quantities and consumed locally (FAO, 2015b).

Pakistan has a diverse environment and hosts a large variety of medicinal plants. These medicinal plants are used locally for the treatment of various diseases as well as being sold commercially. Pakistan is gifted with tremendous natural resources and plants have long been used to cure different human and animal diseases (Shedayi et al., 2014, 2016). Thanks to their life-saving properties, medicinal plants are the most expensive among the NTFPs, and they contribute the biggest share of income. Industrial products, such as resin, vegetable tanning, bhabar grass, Sabai grass, babul bark, dwarf palm leaves (Mazri), and silk cocoons, are collected and used in various large and small industries for the synthesis of a range of products (FAO, 1994).

Conservation of forests is important not only because they provide provisioning services to the locals but also for the sociocultural and regulating services they provide to a wide range of people. Developmental activities have both merits and demerits for forest ecosystems; for example, road construction provides easy access to tourists, but it destroys the forests and their natural systems.

Fisheries

According to the Food and Agriculture Organization of the United Nations, feeding more than 9.7 billion people by 2050 the context of climate change impacts, financial uncertainty, and growing competition for food owing to an exponential population growth trend, especially in developing countries, is one of the greatest challenges to face. The annual per capita fish consumption has grown from 5.2 kg in 1961 to 18.8 kg in 2013 in developing countries, while it has increased from 3.5 to 7.6 kg in low-income countries (FAO-UN, 2016a). Pakistan has an arid climate, but it has great potential for small-scale inland fish farming for local consumption as well for earning foreign exchange through exports (Nazir et al., 2016). The long coastline of 1,050 km in Pakistan provides the best opportunity for marine fishing in an area of approximately 300,270 sq. km. Pakistan's fishing grounds are highly rich in marine life with a vast variety of species having

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commercial value, both for domestic consumption as well as for export. More than one million people depend on the fisheries profession, and they are mainly settled in villages along the coastline (Nazir et al., 2015).

Spatial distribution of fish production was found significantly different among the provinces, while there was a non-significantly increasing trend of fish production at temporal scale. The fisheries and fishing industry are growing in Pakistan, both inland and marine. Marine fish contributes more to the NPV compared to freshwater fish farming. Most fish production is found in the Sindh province, followed by Punjab and Baluchistan. There was an increasing trend over the five-year period of study with an average of 30% in this period because the demand for food increases with increasing population size. The population of Pakistan is increasing with an annual growth rate of 2.6% (Raza and Siddiqui, 2014). There are 760 fish species in total across fresh and marine waters, of which 200 species are economically important; approximately 71% of the fish production in Pakistan is exported (Nazir et al., 2015). Pakistan's contribution to world fish production is 0.30%, which is the lowest in the world market and can be improved by adopting modern techniques (FAO- Fisheries and Aquaculture Department, 2017).

The average annual catch was almost 600,000 tonnes (Nazir et al., 2015) of which most are exported, as noted earlier. Besides exporting fish products, fish is an important source of food for the people of Pakistan, especially those living in Sindh. Seafood is also exported to other provinces, such as from Karachi to Punjab and KPK.

The seafood export rate in Pakistan increased by 49.82 million USD in 2013–2014 as compared to 2012–2013 (Shah et al., 2018) an estimated increase of 12.25% in term of quantity (Nazir et al., 2015). Pakistan exports 60 million seafood products to China and Vietnam. Other markets for Pakistani seafood include Thailand, Saudi Arabia, Malaysia, Bangladesh, Egypt, Hong Kong, Japan, Kuwait, South Korea, and the UAE. (Nazir et al., 2015). Pakistan has a good market for fish products. Inland fish farming is increasing in many provinces to fulfil the demand for protein. The majority of marine fish production is exported to other countries for income generation, and production and export can be increased further by using the latest equipment and techniques.

Climate change and discounting

The world is facing impacts from climate change in the form of global warming, floods, rising sea levels, and drought. Poor people, who depend on natural resources for their livelihood, suffer the most from climate change. Climate change is predicted to have a severe impact on natural resources in the future. This will disturb the processes, functions, and services of ecosystems (Soudzilovskaia et al., 2013). It is important to include climate change impacts in policymaking frameworks (Hermwille et al., 2017). It is thus necessary to estimate the future values for ecosystem services based on current NPVs by employing discount rates on different time horizons. We, therefore, applied three different discount rates (0.74%, 6%, and 11.26%) on three time horizons (2050, 2085, and 2120). With the increasing discount rates and time horizons, the values decreased accordingly. These estimated NPVs for the different time horizons and discount rates will help policymaking bodies, conservation organizations, and researchers assess the impacts of climate change. Discounting is important for the sustainable use of natural resources and development (Gowdy et al., 2010).

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Comparison with other studies

Our results were consistent with those of some previous studies, especially with those focused on food (meat and fisheries), wood (timber and fuelwood), and water for irrigation, similar to how we focused on food (agriculture, fisheries, and livestock), wood (timber and fuelwood), and medicinal plants. Those studies that showed high values of provisioning ES, focused on wetland production, freshwater for drinking, and agriculture products. The studies that reported low values of provisioning ES had focused on hydropower, irrigation, and food provision. The variation in the values of providing ecosystem services is attributed to the geographic, ecological, and climatic factors, which vary from country to country. Our results for the provisioning ecosystem services showed reasonable homogeneity with the results of other studies. However, the previous studies did not link Prov.ES to poverty and food, water, and energy security. In addition, policy recommendations were merely discussed and highlighted. We recommend conducting studies linking Prov.ES with poverty reduction, focusing on major drivers of the services.

Conclusions

Provisioning services provide tremendous benefits to people's livelihoods, including food, water, fiber, medicine, energy, and many others. These services are directly taken from nature in various forms, via crops, vegetables, fruits, livestock, forests, and fisheries. More than 60% of the population of Pakistan lives in rural areas, where people depend on natural resources to fulfil their living requirements. Pakistan's natural resources are being depleted by overexploitation, impacts of climate change, and poor management systems. Among the provisioning services, livestock's contribution was the highest followed by agricultural products, while fisheries and forests contributed the least. This situation is alarming for the forestry sector: only 4% of the total land area of Pakistan is covered by forests, which is why its contribution as a provisioning ecosystem services is very low. Poor forest cover leads to other environmental consequences, such as floods and landslides, which cause major destruction and loss to infrastructure, crops, livestock, and human lives, resulting in mass migration to other areas from 2003 to 2014. Livestock is the major contributor in the ecosystem services, but livestock depend on other ecosystems, such as grassland, forests, and agriculture. Forests also provide habitats for many of the rare, threatened, and endangered species in Pakistan. The rapidly accelerating rate of forest depletion is leading to the extinction of some animals from the wild while others have migrated to more suitable areas in neighboring countries. Forests, peatlands, and pastures act as carbon sinks. Land use degradation causes carbon release into the atmosphere, adding to the global atmospheric carbon, which is the main cause of climate change and global warming. All ecosystem services are interlinked with several tradeoffs. Being an agricultural country, Pakistan needs to improve its agricultural system as most of the people in urban and rural areas depend on agricultural products, while a mixed agriculture system is practiced in most parts of the country. Pakistan needs to enhance the quantity and quality of its crop production for both domestic consumption and exporting as a source of income generation. Sustainable agro-forestry and agro-pastoral systems are suitable for Pakistan with the introduction of the latest technology and biological control methods, instead of traditional farming or high doses of synthetic fertilizers. Pakistan has the potential to increase its fish production for domestic and export purposes by improving management systems and reducing freshwater and marine pollution. It is

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suggested that policies relating to Prov.ES should be reframed for better management, conservation, and utilization purposes. Funds need to be allocated to the research sector, especially universities, to frame policies based on research and on-the-ground realities, keeping the consequences of depleting natural resources in focus in the future.

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Conflicts of Interests. We declare no conflict of interests.

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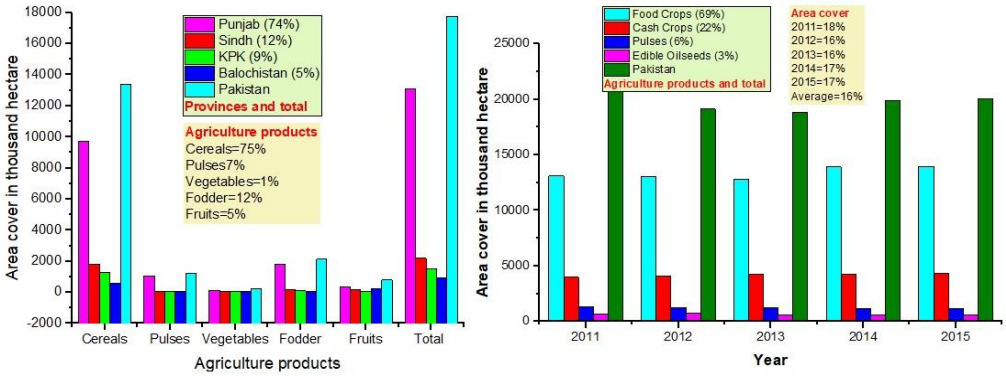
APPENDICES



Appendix A. *Area cover of agriculture products by province from 2011 to 2015. (KPK: Khyber Pukhtunkhwa)*

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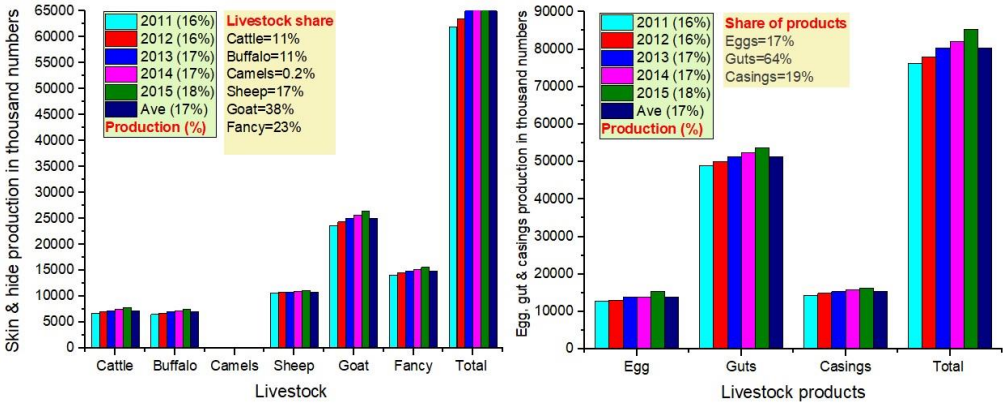
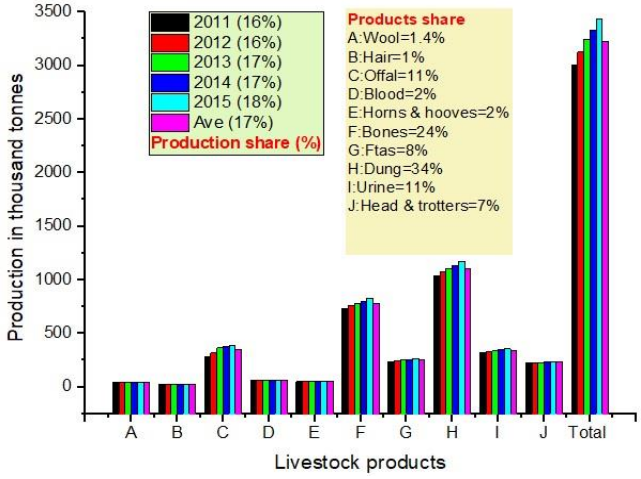
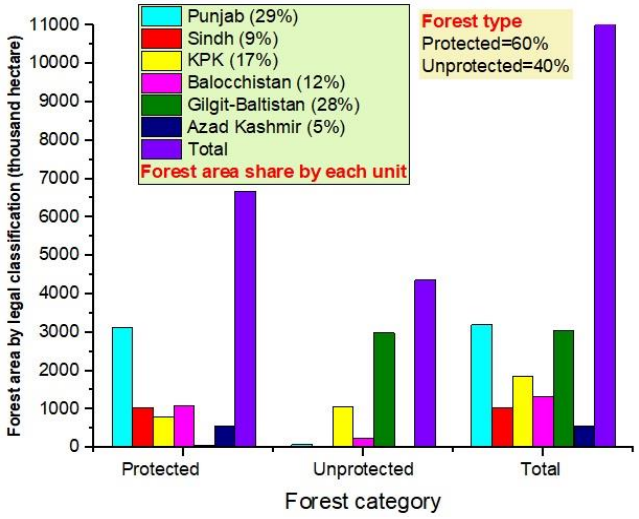


Appendix B. *Skin and hide, eggs, guts, and casings production from 2011 to 2015*



Appendix C. *Other livestock products from 2011 to 2015*



Appendix D. *Forest category, area cover, and distribution by province. (KPK: Khyber Pukhtunkhwa)*

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